A most remarkable campaign has been conducted by M. Teisserenc de Bort, who, with the aid of Scandinavian colleagues, established last summer a kite-flying station in Jutland, Denmark, where aërial soundings were made day and night, wind permitting, during nine months. After the termination of this work the apparatus was transferred to a Danish gunboat, and on a cruise in the Baltic Sea the following extraordinary results were obtained on five consecutive days:—April 22, at an altitude of 9450 feet a temperature of $+14^{\circ}\cdot8$ F. was found; April 23, at 13,500 feet, the temperature was $9^{\circ}\cdot1$; April 24, at 4660 feet, $38^{\circ}\cdot3$. On April 25 an altitude of 19,360 feet, which is probably the greatest height ever reached by a kite, was exceeded, and an instrument on the lower portion of the wire, at a height of 7415 feet, recorded $24^{\circ}\cdot4$. In this flight the total length of the wire was 38,000 feet, and the upper 4000 feet, with the highest registering instrument, broke away, but were recovered. On the morning of April 26 an altitude of 8140 feet, with a temperature of $15^{\circ}\cdot2$, was obtained, and in the afternoon 13,320 feet, with a temperature of $3^{\circ}\cdot2$. Since the gunboat steamed only nine and a half knots, the kites could not be flown when there was a complete absence of wind.

These various experiments amply prove the practicability of the writer's project to investigate the atmospheric strata lying above the doldrums and trade-winds, by means of kites flown from a specially chartered steamship. This plan received the approval of the International Aëronautical Congress at Berlin last year, and an application for a grant to aid its execution is now before the trustees of the Carnegie Institution. On the vessel which the Baltimore Geographical Society sent last month to the Bahamas, Dr. Fassig, of the Weather Bureau, expected to fly kites, but, owing to the substitution of a schooner for a steamer, this could not well be done, and therefore the kites were probably flown only at Nassau. These observations might serve as a starting-point for the work of the expedition proposed by the writer, which would proceed across the equator and be capable of sounding the atmosphere to the height of four miles, notwithstanding the fact that winds either too light or too strong for the kites may be encountered when the steamer is stationary.

THE COUNTY TECHNICAL LABORATORIES, CHELMSFORD.

ESSEX is one of the counties which, since the passing of the Local Taxation (Customs and Excise) Act of 1890, has devoted the whole of the funds thus provided to the purposes of higher education. At first almost the entire grant was distributed among some forty local technical instruction committees for the purpose of lectures and classes in the areas under their supervision, but by degrees the greater part has been diverted to the erection, equipment, or support of secondary and technical schools in the more important centres.

In 1892, when Sir Henry Roscoe and Prof. Meldola were members of the Essex Technical Instruction Committee, the site of an old grammar school in the centre of Chelmsford—the county town—was purchased, and part of the old school buildings were fitted up at a cost of about 300*l.* as the county laboratories for teaching biology and chemistry, the two sciences which are of greatest importance to the principal industries of the county, viz. agriculture, horticulture, dairying and fisheries. In the temporary accommodation thus provided most of the work of the past ten years has been carried on, and readers of NATURE have from time to time had an opportunity of judging its character.

From the commencement until he was appointed agricultural biologist to the Irish Board of Agriculture in the spring of 1902, the committee had the advantage of the services of Mr. David Houston as staff-teacher of biology. Mr. Houston's influence was directed towards basing the teaching of science on practical laboratory work. It thus comes about that the institution has always been known as, and still remains, the Laboratories for Technical Instruction of the County of Essex. Moreover, the subcommittee, which now has the supervision of the laboratories, a committee which, with the single exception of the chairman, entirely consists of Essex farmers, adopted plans for the new buildings, opened by the President of the Board of Agriculture on October 30, which mainly consist of laboratories and work-rooms, and include only one lecture-room in the whole institution.

The part of the old site on which the new buildings are placed is within a stone's throw of the market-place and corn exchange, and the intention is to provide, not merely a technical school for the younger men, but also a centre at which farmers and others can readily obtain scientific and practical information respecting farming and the allied industries. Thus the principal room, near the entrance on the ground floor, is the large agricultural room, provided with demonstration and work tables for the agricultural instruction of students, and also containing an agricultural museum and reference library, together with diagram frames for displaying the most recent results of agricultural experiments. The room will be kept supplied with the agricultural papers, and will serve for the meetings of farmers which are held from time to time on market days to discuss agricultural problems.

On the same floor are the rooms for the head of the chemical and agricultural department, the work-room of the assistant who has the management of the field experiments, a small physical room with dark room for optical and photographic work, the common rooms for men and women students, and one of the biological laboratories.

On the first floor is a chemical laboratory capable of accommodating twenty students at a time; each working bench is provided with drawers and lockers for four sets of students, so that eighty students can be taught in a term. All the students' benches face the demonstration table, and thus the teaching can be carried on by revision, demonstration or experimental work without the students leaving their benches. Adjoining are the balance room and store room, the latter in direct communication with the chemical lecture room, and a private laboratory for the analysis of soils, manures, feeding-stuffs, milk, &c., for farmers, a department of the work which is found to be a most potent means for spreading information.

On the same floor are some of the rooms of the biological department, but shut off from the chemical department and reached by a separate staircase. Thus horticultural students, for whom the biological staff is responsible, are kept separate from the agricultural students, for whom the chemical staff is responsible. The common room for all the male students stands between the two departments. This system of separate staircases has the additional advantage of saving room, for a striking feature of the general plan is that there is only one corridor in the whole building. The biological department includes two large laboratories, each provided with a preparation or private work-room, a lecturer's private room, a store room, and museum galleries. The two laboratories each accommodate twenty students, and, as in the chemical laboratory, the working tables all face the demonstration table and black board.

A cool, lofty and well-lighted basement serves admirably for the dairy. The accommodation includes a milk receiving room, which it is proposed to equip with separator, pasteuriser, and steam apparatus for cleaning milk churns, &c., the dairy proper, with butter churns for twelve students, a cheese-making room, a cheese-ripening room and store. A top floor of six rooms is at present used as a part of the County Education Offices, but these are to be diverted to teaching purposes at the end of two years, when it is expected that the teaching or experimental work of the laboratories will demand increased space. The whole building is lit with electricity. The electric current is also used for motive power where required, and adapted to electrolytic purposes in the chemical and physical laboratories.

Within three-quarters of a mile of the laboratories is the school garden, which has already been planted about five years. It is three acres in extent, and is provided with a students' potting shed and glass houses, and consists partly of botanical plots and partly of fruit, vegetable and flower borders for the practical instruction of gardening students in each branch of horticulture. There is no farm in connection with the laboratories; the agricultural students make excursions to well-managed farms in the neighbour-

hood, and the field experiments are carried out on farms in all parts of the county, this system having the double advantage that manurial trials can be made on every class of land, and that farmers in each district are able to see for themselves the results.

THE NEWCOMEN ENGINE.[1]

A GREAT deal has been written on the steam-engine generally, but the author has not met with any connected record of the invention and construction of the first steam-engine—the atmospheric engine of Newcomen. Unfortunately it does not appear that very detailed information is available, but the author has been able to bring together some facts which, with the aid of appendices contributed by others and some illustrations of the engine itself, may be found to be a useful contribution to place on record in the *Proceedings* of the Institution. There are not many examples of the engine now in existence, and when they are consigned to the scrap heap, the receptacle of great efforts of the past, all will perhaps be forgotten.

Towards the end of the seventeenth century, philosophers and mathematicians searched for a new method of obtaining motive power. Mining was an important industry requiring in most cases a new power, that the mines might be worked to greater depths. Water-power, where available, was often insufficient, and manual and animal power was altogether too small and too expensive for working any but shallow mines. Deep mining was, and is, only possible with pumping machinery. Water-wheels were used for working pumps. The construction of the common pump was known. Papin had proposed to transmit power by means of pistons moving in cylinders acted on by the atmosphere, a vacuum having been formed under the pistons by the explosion of gunpowder, and he even hinted that it might be done by steam.

It was claimed for Papin that he invented the steam-engine, because in 1685, in one of his letters, he illustrated what was known of the properties of steam by saying that if water was put in the bottom of a cylinder under a piston, and the cylinder be put on a fire, the water would evaporate and raise the piston, and that if, after the piston had been raised, the cylinder were removed from the fire and cooled, the steam would condense and the piston would descend; but this was only an illustration of common knowledge. Sir Samuel Morland had, in 1683, stated[2] that steam occupied about two thousand times the space of the water from which it was produced, and made some calculations as to the powers to be obtained from different sized cylinders, but suggested no practical mode of operation. An experiment to determine the density of steam was made by John Payne in 1741. Payne concluded, as the result of his experiments, published in the *Phil. Trans.*, vol. xli. p. 821, that one cubic inch of water formed 4000 cubic inches of steam. Beighton calculated, from an experiment with the Griff engine, the second Newcomen engine erected, that the specific volume of steam was 2893.

The properties of steam were, probably, no better known to philosophers than to the ordinary observer who had seen the lid of a kettle dance under pressure, or steam issue from the spout. The only practical application of steam was made by Savery, who, in 1696, described his invention in a pamphlet entitled "The Miner's Friend." Savery's engine was a pistonless steam pump—in fact, the pulsometer of to-day without its automatic action. It remained for Newcomen to associate the bits of common knowledge in his mind for inventing the steam-engine. He was a blacksmith, probably accustomed to invent methods of construction in the prosecution of his art. At that time mechanics were more self-reliant than they are now. He knew from experience what a lever was, a pump, a piston, a cylinder, a boiler, and he knew that the atmosphere had pressure, and that steam possessed a far greater volume than the water which produced it. It did not require much more than common knowledge and observation to realise that. To produce the steam-engine from such known facts required invention. Philosophers probably knew what might be done, but Newcomen had the advantage of seeing what could be done, and he did it. The engine, when produced, was imperfect, but defects became obvious to the designers and constructor of steam-engines, and the want of perfection at the present day is not from want of theory, but because of practical limitations and want of practical invention.

At this distance of time it is difficult to appreciate the invention required to produce the atmospheric engine from the crude ideas of Papin and others. It appears, from papers in possession of the Royal Society, that Dr. Hooke had demonstrated the impracticability of Papin's scheme, and, in a letter addressed to Newcomen, advised him not to attempt to make a machine on that principle, adding, however, that if Papin could produce a speedy vacuum, his work would be done.[1] A great deal of controversy hangs about this as about all things historical, and little is to be gained by minute research into disputed claims. What we do with certainty know is that with the common knowledge existing, and the mechanical contrivances available, Newcomen alone succeeded in making a workable engine.

In 1698, Thomas Savery, of London, obtained a patent for raising water by the elasticity of steam.[2] It is stated in many popular histories that in 1705 Thomas Newcomen, John Cawley, of Dartmouth, and Thomas Savery, of London, secured a patent for "condensing the steam introduced under a piston and producing a reciprocating motion by attaching it to a lever," but no record of such a patent exists in the Patent Office. Stuart gives a list of patents commencing with 1698, and in that list is one said to have been granted in 1705. Dr. Pole, author of "The Cornish Engine," had a search made at the Patent Office and no such record could be found. It is possible that Savery's patent was thought to cover Newcomen's invention (as Savery was associated with Newcomen).[3] This was sixty-four years before Watt invented his separate condenser. Very little is known of Newcomen. It is recorded that he was a blacksmith or ironmonger residing at Dartmouth, in Devonshire, and that he was employed by Savery to do some work in connection with his water-raising engines. In this way he had some experience in the condensation of steam.[4]

Newcomen appears to have conceived the idea of using a piston for giving motion to pumps. He became associated with John Cawley, a glazier of Dartmouth, probably for business reasons. His connection with Savery was doubtless because of Savery's patent for condensing steam for raising water. He must, however, have been a good mechanic, because the construction of such an engine at a time when there was no previous experience or data to guide him was a task of no ordinary magnitude. He could not get workmen skilful enough to do his work until, erecting an engine near Dudley in 1712, he secured the assistance of mechanics from Birmingham.

The Newcomen engine was soon brought into use, for in 1712 Newcomen, through the acquaintance of Mr. Potter, of Bromsgrove, erected an engine, near Dudley Castle, for a Mr. Back, of Wolverhampton. The cylinder of this engine was surrounded with water. The piston was packed and had a water seal. It is reported that by accident a hole in the piston admitted water into the cylinder, and the condensation thereby became so rapid compared with that produced by cooling the cylinder from the outside that the engine worked much quicker. This may or may not be correct, but it is certain that, by accident or design, the first improvement in the engine was condensation by injection in the cylinder. It appears that the second engine was erected at the Griff Colliery, in Warwickshire, in 1715. It had a 22-inch cylinder. At this time the cocks and

[1] Abstract of a paper read before the Institution of Mechanical Engineers on October 16 by Mr. Henry Davey.

[2] See Tredgold's "Steam Engine."

[1] See Stuart's "History of the Steam Engine."

[2] Savery was born at Shilston, near Modbury, in Devonshire, in 1650; died in London 1715.

[3] It appears that there is every reason to believe that Newcomen had no patent, and that his invention was supposed to be covered by Savery's patent of 1698, and that the latter was kept in force for thirty-five years, the original patent having been extended for twenty-one years.

[4] Newcomen was born at Dartmouth about the middle of the seventeenth century, and died in London in 1729. It is stated in Haydn's "Dictionary of Dates" that at the time of his death he was in London trying to secure a patent. A sketch of the house in Dartmouth occupied by Newcomen when he invented the steam-engine is shown in a pamphlet published in 1869 for Mr. Thomas Lidstone of Dartmouth.